MUTUAL IMPEDANCE OF SLOT ANTENNAS

BY

HAN KUEI CHEN

B.S., National Central University, China, 1939
M.S., University of Michigan, 1947

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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MUTUAL IMPEDANCE OF SLOT ANTENNAS

This thesis consists of four parts. The first part deals with the mutual impedance of slot in a plane. The second part deals with the mutual and self impedance of axial slot in a cylinder by the induced e.m.f. method. The third part deals with an approximate solution to the mutual impedance between parallel axial slots in a cylinder. The fourth part deals with the self impedance of an axial slot in a cylinder by Holt's transmission line approach using a different method of obtaining G, which is the line conductance.

It is shown that the mutual admittance of slots in a plane, Y^s_{12}, is related to the mutual impedance of their complementary flat dipoles, Z^d_{12}, by the relation $Z^d_{12} / Y^s_{12} = \frac{1}{4} \eta^2$. For each slot in a plane case, a duality flat dipole case can always be set up. By a comparison of the boundary conditions and the wave equations for the two cases, a relation between the fields of one and those of the other is derived. From this relation the equality $Z^d_{12} / Y^s_{12} = \frac{1}{4} \eta^2$ is established. It was stated both in Booker's paper and Watson's book that $Z^d_{12} Z^s_{12} = \frac{1}{4} \eta^2$, where Z^s_{12} is the mutual impedance of the slots in a plane. It is pointed out that this statement is incorrect. The mutual admittance and the mutual impedance are not reciprocally related to each other.

For a finite axial slot in a cylinder, it is experimentally found that voltage distribution along the slot can be approximately expressed by $V(z) = V_m \sin \beta_s (1 - |z|) = V(0) \sin \beta_s (1 - |z|) / \sin \beta_s 1$, where β_s is a phase shift constant different from that in free space. It is shown that for such a finite axial slot case, an approximate current distribution around the slot can be assumed. It follows as a consequence of the fact that for this case, the wave guide phenomenon is predominant. The problem of an infinitely long axial slot-in-cylinder with a sinusoidal standing wave excitation $V(z) = V_m \sin \beta_s z$ is solved. The technique used is to resolve the sinusoidal satnding wave excitation into two traveling wave

excitations. The assumed current distribution for the finite slot case is taken from the corresponding section of the infinitely long slot case. After the current distribution is assumed, the impedance is calculated by the induced e.m.f. method. Expressions for the mutual impedance between parallel axial slots and colinear axial slots and the self impedance of an axial slot have all been derived. No calculations have been carried out but it is believed that these expressions will lead to a numerical answer if calculations were made.

From the solution to the field for an infinitely long axial slot in a cylinder with a sinusoidal standing wave excitation, an approximate solution to the problem of mutual impedance between parallel axial slots in a cylinder is obtained. A postulation has been used. This approximate solution, which has been given a numerical result, can be used in the network analysis of slots in a cylinder.

The problem of self impedance of an axial slot in a cylinder was solved by Holt by considering it as a short circuited section of uniform transmission line. He derived the reactive part of the transmission line constants, the susceptance B and the reactance X, from a corresponding uniformly fed infinitely long slot in a cylinder. He derived the real part of the admittance of the line constants, or the conductance G, from the power radiated by the slot, which in turn is found from an assumed current distribution around the slot. The expression of G is complicated. In this thesis, a new expression for G is derived. Using this G and the same B and X that Holt derived, a more practical solution to the self impedance problem is obtained. The new expression for G follows as a result of a new method of obtaining the distant field. The method is to consider the slot as a magnetic dipole adjacent to the cylinder. It is more rigorous than Holt's method and thus enables the range of validity of Holt's solution to the impedance problem to be extended. The magnetic dipole approach to the distant field is distinctive. It differs from all the other methods which have been used.

VITA

The author, Han Kuei Chen, was born October 5, 1918 at Changchow, Kiangsu, China. He graduated from the National Central University, China, with a B.S. degree in Electrical Engineering in 1939. After that he worked as an assistant in the same University for three years. Then he joined the National Resources Commission of China as an engineer. He remained with this Commission until 1946 when he was sent to the United States jointly by the Commission and the Ministry of Economic Affairs of China to participate in a training program sponsored by the Radio Corporation of America. He arrived in the United States but the training program was postponed. He then attended the University of Michigan and received the degree of M.S.E.E. in 1947. In February, 1948 he transferred to the University of Illinois and worked part time in antenna research as a special research assistant. For the year 1949-1950, he was a fellow in the Electrical Engineering Department of the University of Illinois. He was elected to the Society of Sigma Xi as an associate member in 1947 at the University of Michigan and became a full member in 1950 at the University of Illinois.

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